Indian J. Phys. 43, 431—438 (1969)

Studies on some microstructures on octahedral faces of natural diamonds

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(*Received* 16 *August* 1969)

Diamond octahedra having large steps on their faces have been examined by keeping the axis of the microscope equally inclined to all the four [111] faces meeting at one corner. Some of the steps show 'quadrons' similar to such features on (100) natural faces. Further tilt revealed other steps on which trigons similar to those observed on natural (111) faces have been found. It is conjectured that growth on different forms of diamond takes place by the depositions of layers parallel to the faces of the form of the crystal.

Introduction

Since growth and dissolution of crystals proceed on the faces of a crystal, the crystal surfaces are the right places at which the phenomena concerning crystal growth and dissolution are most vividly reflected. It is therefore likely that the study of the structure of crystal faces, may be able to predict the mechanism, process and history of crystal growth and dissolution. It is probably with this view in mind, that a number of investigators have carried out the studies on the microstructures of natural diamonds. Chief amongst these are, Fersmann and Goldschmidt (1911), Vanderveen (1913), Sutton (1928), Williams (1932) and Tolansky and his school 1955, 1960). Recently Varma (1967a, 1967b, 1967c) has made a critical study of all the different forms of diamonds. He has conjectured from his studies that growth in all forms of diamond occurs by the deposition of layers parallel to (111) planes irrespective of whether the crystal is an octahedron, a cube or a dodecahedron. According to him even the possibility of growth to occur on (100) and (110) planes to form the cube or the dodecahedron is not considered. It is rather difficult for the authors to conceive why growth should not have taken place on (100) and (110) planes at least in those crystals which are of the cubic and dodecahedron form.

While examining natural diamonds, quite often one observes several steps of quite large step heights on their finished surfaces. It appears that none of the previous workers was interested in the studies of such steps. It is well known according to the theory of crystal growth (Volmer 1939, Kossel 1927, Stranskii 1928, 1949 and Becker & Doring 1935) that growth preferentially takes place along the surface steps and kinks. It was therefore considered that a critical study of these steps and kinks on the surfaces of natural diamonds should be very interesting and encouraging since such studies might reveal a great deal of information about the mechanism of growth of the crystal which is technically a very important substance. It is with this aim that the present work on the studies of steps on octahedral faces of diamonds was undertaken.

Experimental

In order to examine the surface of the steps on [111] faces of diamond the crystal was set such that the (111), ($\bar{1}11$), ($\bar{1}\bar{1}1$) and ($1\bar{1}1$) faces were equally inclined to the axis of the microscope i. e. an imaginary (100) plane of the crystal was normal to the axis of the microscope, as shown schematically in figure 1(*a*). For observing those steps

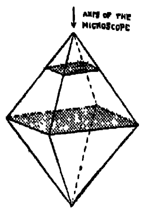

Figure 1(a). Schematic diagram showing an imaginary (100) plane normal to the axis ofthe microscope.

whose surfaces were (111) (schematic diagram of figure 1(c)) the axis of the microscope was further tilted and made perpendicular to them.

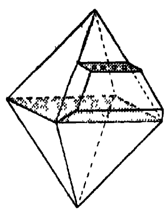

Figure 1(b). Schematic diagram showing (100) step.

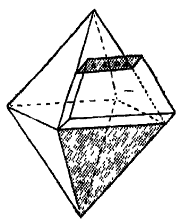

Figure 1(c). Schematic diagram showing (111) step.

Epignost and Vickers's projection microscopes were used for the investigations and about 160 natural octahedral faces were studied. The diamond octahedra were all obtained on request from the Diamond Research Laboratory, South Africa. Out of all the surfaces of the steps examined, twenty four steps showed the quadrilateral pits known as 'quadrons' (Tolansky & Sunagawa 1959) and an equal number showed the triangular pits known as 'trigons'. In some cases the pits were numerous and in others only few. It was found that on one crystal the surfaces of all the steps showed quadrons, while on other either trigons or quadrons were observed. Out of number of observations made we describe here only few of them which are typical.

Observation

1. *Quadrons*

It may be pointed out that all the steps whose surfaces were examined were lying in <110> direction. When the crystals were examined with the axis of the microscope perpendicular to (100) planes, number of quadrons were seen at some places as shown in figures 2 (×800) and 3 (×1000), which are the photomicrographs of surfaces of two different steps on an octahedral face of a crystal and are representative of all such features on the remaining twenty two faces. In order to resolve the pits better, some of the steps showing such features were examined by electron microscopy by preparing a single stage carbon replica as reported by Patel & Patel (1968). In fact it was very difficult to prepare the replicas from such steps because of uneven surface but with repeated efforts the authors were successful in getting the replicas of the surfaces of the steps. Thus figure 4 (×8500) is the electron micrograph of the surface of a step on the octahedral face. Quadrons similar to those observed on natural (100) faces are

Figure 2. (×800) quadrons in (100) steps.

very clearly seen in the picture. These features are observed on the two steps seen crossing the face shown in figure 5 ($\times 55$). The steps are marked as AB and CD in the figure. The steps were measured and found to be 55 μ and 22 μ respectively.

Figure 3. ($\times 100$) quadrons in (1000) steps

Figure 4. ($\times 8500$) Electron micrograph showing quadrons in a (100) step.

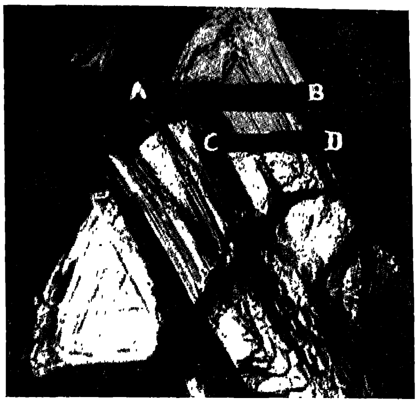

Figure 5. (×55) Octahedral face showing the steps in which quadrons are observed.

2. *Trigons*

During the examination it was found that in some cases the axis of the microscope was required to be titled more to make it perpendicular to the surface of the step. On these steps trigons similar to those observed on natural (111) faces were observed. Figure 6 (×55) represents the photomicrograph of a surface of a step on which the trigons are observed. In order to see these trigons more clearly a picture was taken at a higher magnification. Thus figure 7 (×450) is a magnified photograph of a region shown in figure 6 in which the trigons are very distinctly seen. The octahedral face on which a step having the surface markings described above is shown in figure 8 (×55). It is only in such steps that the trigons mentioned above have been observed.

Figure 6. (×55) Trigons in (111) step.

Figure 7. (×450) Trigons in (111) step at a higher magnification.

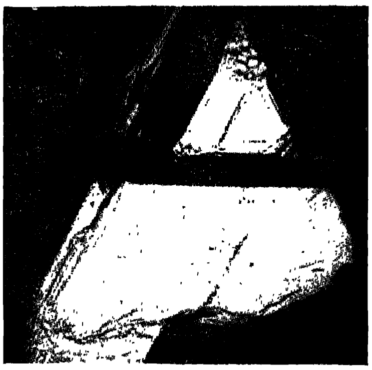

Figure 8. (×55) Octahedral face showing steps in which trigons are seen.

Discussion

That the steps observed on (111) faces of diamond all lie in <110> direction suggests that they might have been formed due to the termination of either (100) or (111) faces on the (111) planes of observation. According to theory of crystal growth (Stranskii 1928, 1949) for growth to take place on flat crystal faces the probability for the growth to proceed is more at the kinks or steps upon them. It is therefore more likely for the growth to proceed on the surfaces of the step rather than elsewhere on the surface on which these steps are observed. The mechanism of growth of the crystal will therefore be revealed by the microstructures on the surfaces of the steps.

Despite existing differences in the interpretation of trigons and quadrons i. e. whether they are formed due to growth or by dissolution there is agreement that trigons are seen only on the (111) plane and quadrons only on the (100) planes in diamond. That the microstructures on the surfaces of the steps examined in the present work show trigons similar to those observed on (111) natural faces and quadrons similar to those observed on (100) natural faces suggests that before the growth ceased (111) and (100) planes might also be the surfaces on which the growth might be taking place. The fact that a large number of steps have been found to have 'quadrons' on their surfaces suggests that growth might also proceed by deposition of layers along (100) planes just as it could take place by deposition of layers parallel to (111) faces. In fact, it is difficult to conceive how growth can proceed by depositing (111) layers in the case of a cube. The answer is, as in the case of an octahedron growth proceeds by deposition of layers parallel to (111) planes, the growth in the cube form of the crystal might also proceed by depositing layers parallel to (100) planes. It seems to us more logical and appropriate to think on these lines rather than to say that growth in all forms of diamond proceeds by the deposition of (111) layers. In fact the present work has clearly shown that even in the octahedron form of diamond at some place the growth in all forms of diamond proceeds by the deposition of (111) layers. In fact the present work has clearly shown that even in the octahedron form of diamond at some place the growth proceeds by depositing layers parallel to (100) planes while at others it might proceed by depositing layers parallel to (111) planes. This view is supported by the existence of trigons on the surfaces of the steps of some crystals and quadrons on the remaining ones.

Thus the authors are of the view that growth will proceed on different forms of the crystals in different manner depending upon the form of the crystal. According to this view in the case of dodecahedron the growth might proceed by depositing layers parallel to (110) planes.

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